Jan. 11, 1955 R. M. PURDY ET AL 2,699,158

ELECTRICAL APPARATUS

Filed May 8, 1950

Fig. 2.

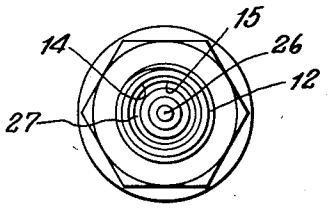
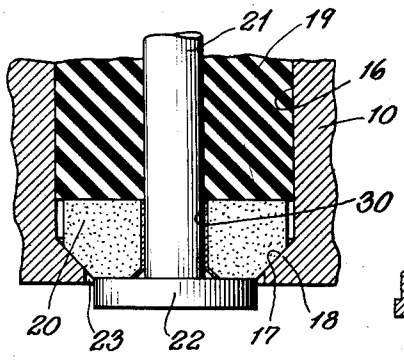


Fig. 3.



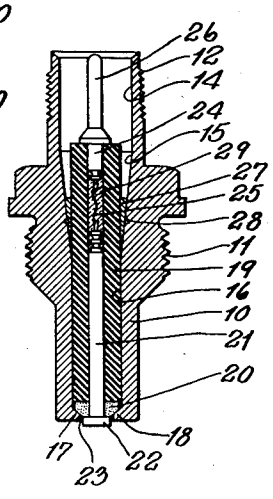


Fig. 1.

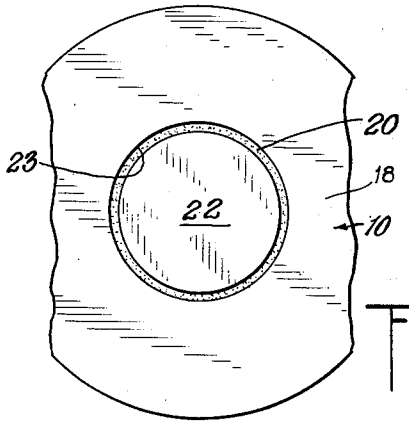


Fig. 4.

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United States Patent Office 2,699,158
Patented Jan. 11, 1955

2,699,158

ELECTRICAL APPARATUS

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Application May 8, 1950, Serial No. 160,762

12 Claims. (Cl. 123—169)

This invention relates to electrical apparatus and more particularly to devices adapted for use in electrical circuits for creating electrical spark discharges between spaced electrodes.

One of the objects of the present invention is to provide a novel spark plug or igniter device adapted for use in ignition systems for igniting combustible charges in engines or the like.

Another object of the invention is to provide novel apparatus of the above type whereby high energy sparks may be created across a relatively wide gap at low voltages.

A further object is to provide a spark plug or equivalent device which will operate satisfactorily and reliably under adverse conditions which would cause certain failure of operation in known types of devices under corresponding operating conditions.

Still another object is to provide a spark plug or igniter which will fire or spark when relatively low voltages are impressed across the electrodes thereof, thereby making it possible to greatly simplify the mechanical construction while maintaining an ample safety factor insofar as flash-overs and the like are concerned.

A still further object is to provide a device of the above character embodying a novel spark gap construction which will function inherently to obviate serious fouling or shunting of the gap by conductive foreign matter and hence, to prevent short-circuiting of the gap and consequent failure of operation.

Another object is to provide a spark discharge device of novel construction which is adapted to initiate a spark discharge from a source of electrical energy, the voltage of which is materially below the normal break-down or spark-over voltage of the gap.

Another object is to provide a novel ignition device for combustion engines which is so constructed as to substantially eliminate all danger of pre-ignition as a result of over-heating of the parts exposed to the combustible gases.

Another object is to provide an electrical device embodying a spark gap consisting of spaced electrodes and novelly constructed from a small number of simple parts which may be readily manufactured and assembled into a sturdy and efficient unit at low cost.

The above and further objects and novel features of the present invention will more fully appear from the following detail description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and are not intended as a definition of the limits of the invention.

In the drawings wherein like reference characters refer to like parts throughout the several views,

Fig. 1 is a sectional elevation view of one form of spark gap device embodying the present invention;

Fig. 2 is a top plan view of the device of Fig. 1;

Fig. 3 is a detail sectional view on an enlarged scale of the lower portion of the device of Fig. 1; and

Fig. 4 is a bottom view of said device on the same scale as Fig. 3.

The single embodiment of the invention illustrated in the drawings, by way of example, is in the form of a spark gap or sparking device commonly known as an igniter or spark plug adapted for use in the ignition systems of combustion engines, such as reciprocating engines and so-called jet or direct expansion engines. As shown, said device comprises a tubular metallic body or shell **10** which is provided with external screw threads **11** or

other suitable known means for effecting attachment thereof to an engine or other support. The upper end of shell **10** is externally threaded at **12** or provided with other suitable known means for attachment thereto of a shielded supply cable or conductor (not shown) and the upper enlarged portion **14** of the bore through shell **10** serves as a receptacle or well for the terminal of said supply or input conductor. Below bore portion **14** is a tapered bore portion **15** and below it is a substantially cylindrical portion **16**. The lowermost end of the shell bore is further reduced to form an internal tapered or conical seat **17** on an annular flange **18** which serves or functions as a ground electrode.

Supported in a novel manner in shell **10** and in operative spark gap relation with electrode **18** is a novelly constructed center electrode assembly. As illustrated, said assembly comprises a tubular electrical insulator **19** made of ceramic, aluminum oxide or other suitable known insulating material and having a relatively close sliding fit in cylindrical bore portion **16** of the shell. For a purpose to more fully appear hereinafter, a ring **20** of high resistance or semi-conductive material is assembled in end-to-end engagement and axial alignment with insulator **19** on electrically conductive means extending through the bore of the insulator. To insure concentricity of the assembled parts and to avoid excessive electrical contact with shell **10**, the maximum outside diameter of ring **20** is preferably somewhat less than the outside diameter of insulator **19** and the diameter of bore portion **16**. The internal diameter of the resistor or semi-conductor **20** is somewhat greater than the diameter of the bore through tubular insulator **19** and is preferably coated with an insulating glaze **30** to suitably insulate the same from spindle **21**. The outer diameter of resistor ring **20** could be similarly glazed, if desired. The lower or outer portion of the circumferential surface of ring **20** is tapered or cone-shaped to match and engage the conical seat **17** whereby said ring is centered or axially aligned with the shell and the other elements of the center electrode assembly.

The electrically conductive means which extends through and is insulated from the shell by insulator **19** may for the most part be of any suitable known construction. In the form shown said means consists of a center electrode member comprising a spindle **21** and an enlarged head portion **22** which, in the assembled unit, forms an annular spark gap **23** with electrode **18** and engages the lower flat or radial surface of ring **20**. Extending into the upper end of insulator **19** is a terminal member **24** which may be electrically connected to spindle **21** by means of a small wire conductor **25**, the ends of which may be brazed or soldered in transverse holes in members **21** and **24** or otherwise electrically connected thereto. The adjacent ends of said terminal and spindle may be of reduced size and provided with suitable grooves or the like for interlocking with a known sealing compound **29** that fills the space within the insulator around said ends and wire **25**. In one satisfactory embodiment the wire **25** consists of a strand of molybdenum wire having a diameter of .015 inch and the sealing compound consists of a hardened fused mixture of "pyrex" glass (75% by weight) and lead oxide (25% by weight). The outer end of terminal **25** may compise one of the mating separable parts of a plug and socket connector of known construction, the plug part **26** being shown by way of example.

After the above described center electrode assembly is inserted in shell **10** with resistor ring **20** in engagement with conical seat **17**, a soft metallic ring or bushing **27** is pressed between insulator **19** and the tapered bore **15** in the shell. The bushing **27**, which may consist of substantially pure copper, is first coated with a soldering or brazing flux, such as borax and then cold-pressed into shell **10** around the insulator under a pressure of about 2200 lbs. while the shell and center electrode assembly are held in assembled concentric relation by suitable fixtures. The structure is then locally heated, such as by a plurality of spaced gas flames, in the region of the inner or lower tip portion of the bushing **27** to a temperature of about 1100 to 1300 degrees F. while applying a similar axially directed pressure on the bushing to further press

it into the tapered annular recess between the insulator and the wall of bore **15**. A groove **28** or equivalent indentation may be provided in said wall for locking the bushing and shell against relative axial movement. A similar groove may also be provided in the insulator within sleeve **27**.

The inner edge or surface of electrode flange **18** may be cylindrical and extend parallel to the cylindrical outer surface of electrode **22** as shown, but either or both said surfaces may be conical and converge with the other toward resistor ring **20**. The lowermost plane or radial surface of ring **20** preferably has a diameter equal to or less than the diameter of electrode head **22**. The tapered surface of ring **20** extends from the upper surface of head portion **22** and across gap **23** to the tapered surface **17** of electrode **18**. In order to provide better assurance of adequate electrode surface and satisfactory operation under all operating conditions, the head of center electrode **22** projects beyond and extends below the lowermost end of shell **10** and hence, beyond ground electrode **18**, so that a spark or arc may readily form between the extended portion of the center electrode and the lower surface of the shell. The extended portion of electrode **22** also serves to deflect combustible gases into the gap **23** and thus facilitate combustion thereof.

In one satisfactory embodiment shell **10** and hence, ground electrode **18**, is made of stainless steel and center electrode **21**, **22** is made of stainless steel or "nichrome," a nickel alloy. A composition consisting of 8.5 parts (by weight) of silicon carbide, one part of cobalt oxide, 2 parts of aluminum oxide and .5 part of urea formaldehyde resin has proved satisfactory for making ring **20**. The glaze coating **30** may compries 14 parts (by weight) of frit, 1 part ball clay and 5 parts zircon. The radial width of gap **23** between the adjacent parallel surfaces of electrodes **18** and **22** along the conical surface of resistor **20** should be approximately .020 inch or greater.

The device hereinabove described may be used in any electrical circuit capable of impressing approximately 500 volts or more across the gap **23**, but preferably the device is used in conjunction with a condenser which when operatively connected to terminal **26** and charged to the desired voltage will discharge across the gap. The resistor **20** being in engagement with the gap electrodes and bridging the gap at one end thereof, makes it possible to create a high energy arc across the gap at a voltage which is very considerably less than the voltage which would be required to bridge the same air gap in the absence of the resistor. It is believed that when a voltage insufficient to bridge the gap with an arc is impressed across the electrodes a small amount of electrical energy passes through or along the conical surface of resistor **20** and ionizes the gaseous medium between the gap electrodes thereby reducing the resistance of said gaseous medium to a level such that a low voltage spark or arc will occur. The terminal **26** is usually connected to the source of energy and electrode **28** is customarily at ground potential. Successive sparks may occur at different points along the annular gap **23** and are effective to burn or drive out of the gap any accumulation of carbon, lead or other foreign matter which might otherwise create a permanent low resistance path between the gap surfaces, a condition known to the art as "fouling."

There is thus provided a novel spark gap device which is particularly adapted for use in installations where a high energy arc or hot spark is desired, such as in combustion engines and the like, and particularly in jet type engines. The device contemplated may be rapidly and inexpensively constructed from a few simple parts, the structure being such that high energy sparks may be created at low voltage with heretofore unsurpassed efficiency and reliability. The gap is self-cleaning since the hot spark produced serves to burn or blast away from the gap substances which would otherwise cause severe fouling and ultimate failure. The simplicity of the structure contributes to rapid heat dissipation and hence to the elimination of the danger of pre-ignition. Since firing will occur with the present device at voltages below the normal break-down voltage of a comparable air gap, substantial erosion of the gap electrodes will not result in failure, thereby materially increasing the useful life of the device.

Although only a limited number of embodiments and modifications of the invention have been illustrated in the drawings and described in the foregoing specification, it is to be expressly understood that this invention is not limited thereto. For example, the ground electrode **18** need not be integral with or of the same material as shell **10** and the resistor ring **20** may be made of materials other than the composition specifically suggested, other examples being disclosed in the co-pending application of Tullio Tognola Serial No. 98,093, filed June 9, 1949, for "Electrical Apparatus." The electrodes **18** and **22** may consist of inserts made of tungsten or other electrode material and brazed or mechanically secured to shell **10** and spindle **21**, respectively. The wire conductor **25** and insulating seal **29** may be replaced by a conductive sealing compound of known composition, or in some installations, the center electrode may be constituted by a unitary bar. Various other changes may also be made in the relative sizes, design and arrangement of parts illustrated, as well as in the composition of the materials suggested without departing from the spirit and scope of the invention as will now be apparent to those skilled in the art.

What is claimed is:

1. A spark gap device comprising a tubular metallic shell having an internal flange constituting a gap electrode, a center electrode assembly insertable into said shell as a unit and including a tubular insulator and an electrode insulated thereby from the shell and in spark gap relation with said gap electrode, said assembly being in direct engagement with and supported by said flange, and a soft metallic annular bushing wedged between said assembly and said shell and constituting the sole means for retaining the assembly in the shell and in firm engagement with said flange.

2. In apparatus of the class described, a tubular metallic shell, gap electrode means forming a conical seat in one end of said shell, means including an electrode in spark gap relation with said gap electrode means, and an electrical resistor bridging the gap between said electrode means and said electrode, said resistor being spaced from said shell and having a conical external surface engaging said seat and converging toward said gap, both said electrode means and electrode having portions projecting beyond the bridging surface of said resistor to form with said surface a small channel-shaped annular spark gap.

3. A spark gap device comprising an annular electrode, a center electrode concentrically disposed in said annular electrode and forming therewith an annular channel-shaped spark gap, said center electrode extending beyond one end of said gap, and an annular resistor engaging said electrodes and bridging the other end of said gap, said annular electrode and resistor having engagement only along engaging conical seats thereon which converge toward said gap, and said resistor being of relatively uniform composition throughout.

4. A device as defined in claim 3 including a spindle on said center electrode extending through said resistor and an insulating coating on the inner surface of said resistor.

5. Apparatus of the class described comprising a tubular metallic shell, means constituting a gap electrode at one end of said shell, a center electrode assembly insertable into said shell as a unit and comprising a tubular electrically conductive member of relatively uniform composition throughout having high electrical resistance, a tubular insulator and a conductive center electrode extending through said member and insulator and being in spark gap relation with said gap electrode, said member being spaced from said shell and having a conical external surface seated on a conical surface of said gap electrode, said conical surface converging toward the spark gap between said electrodes, and means for securing said assembly in the shell and for holding said member in firm engagement with the conical surface of said gap electrode.

6. Apparatus of the class described comprising a tubular metallic shell, an internal flange at one end of said shell constituting a gap electrode and forming an internal conical seat converging toward said one end of the shell, a tubular resistor spaced from said shell and having a conical external surface engaging said conical seat, a tubular insulator engaging but bodily separate from said resistor and having a sliding fit in the bore of said shell, wedge means pressed between said shell and insulator for maintaining said insulator in the shell and holding said resistor in firm engagement with the insulator and said gap electrode, and center electrode means extend-

ing through said insulator and resistor, said electrode means having an enlarged head portion engaging the end face of said resistor and positioned in spark gap relation to a portion of said gap electrode which projects beyond said end face of the resistor.

7. Apparatus of the class described consisting of a tubular metallic shell having a portion constituting a gap electrode, a tubular insulator, electrically conductive means extending through said insulator and having an enlarged end portion projecting therefrom into spark gap relation with said gap electrode, and an annular resistor bodily separate from said insulator and surrounding said conductive means with its end faces in firm engagement with the end of said insulator and said enlarged end portion of said conducting means, the only surface of said resistor having engagement with said shell being an external conical surface seated on a conical surface of said gap electrode, said conical surfaces converging toward the gap between said electrode and said enlarged end portion.

8. Apparatus as defined in claim 7 wherein the surface of the bore of said resistor is glazed to insulate the same from said conductive means.

9. In apparatus of the class described, a tubular metallic shell, an annular electrode at one end of said shell, a tubular resistor consisting wholly of a composition offering high resistance to electrical current and engaging said electrode, a tubular insulator engaging one end face of said resistor and having a sliding fit in the bore of said shell, means interposed between said insulator and a tapered wall portion of the bore in said shell for retaining the insulator in the shell and holding the

resistor in firm engagement with said electrode, and electrically conductive means extending through said insulator and resistor and comprising an enlarged portion engaging the other end face of said resistor and projecting beyond the latter in spark gap relation with said annular electrode.

10. Apparatus as defined in claim 9 wherein said annular electrode and said resistor have engaging conical surfaces.

11. Apparatus as defined in claim 9 wherein the bore through said resistor is co-axial with and larger than the bore in the adjacent end of said insulator.

12. Apparatus as defined in claim 9 wherein the surface of the bore through said resistor is insulated from said conductive means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,155,481	Fenn	Apr. 25, 1939
2,272,558	Hall	Feb. 10, 1942
2,356,104	Tognola	Aug. 15, 1944
2,359,421	Higgins	Oct. 3, 1944
2,471,070	McCarthy et al.	May 24, 1949
2,507,278	Smits	May 9, 1950
2,527,489	Smits	Oct. 24, 1950

FOREIGN PATENTS

22,517	Great Britain	Sept. 28, 1910
536,460	Great Britain	May 15, 1941